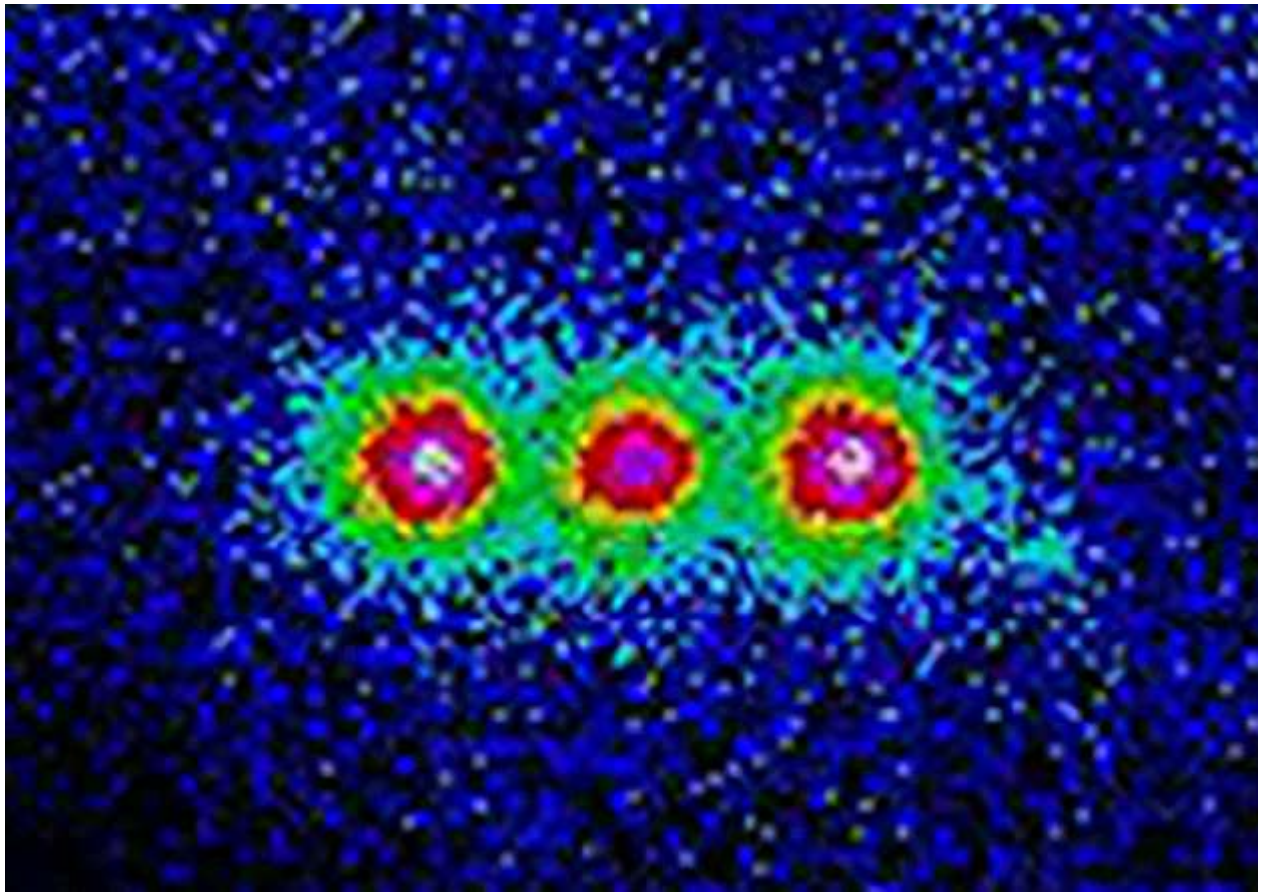
Pre-AP Chemistry

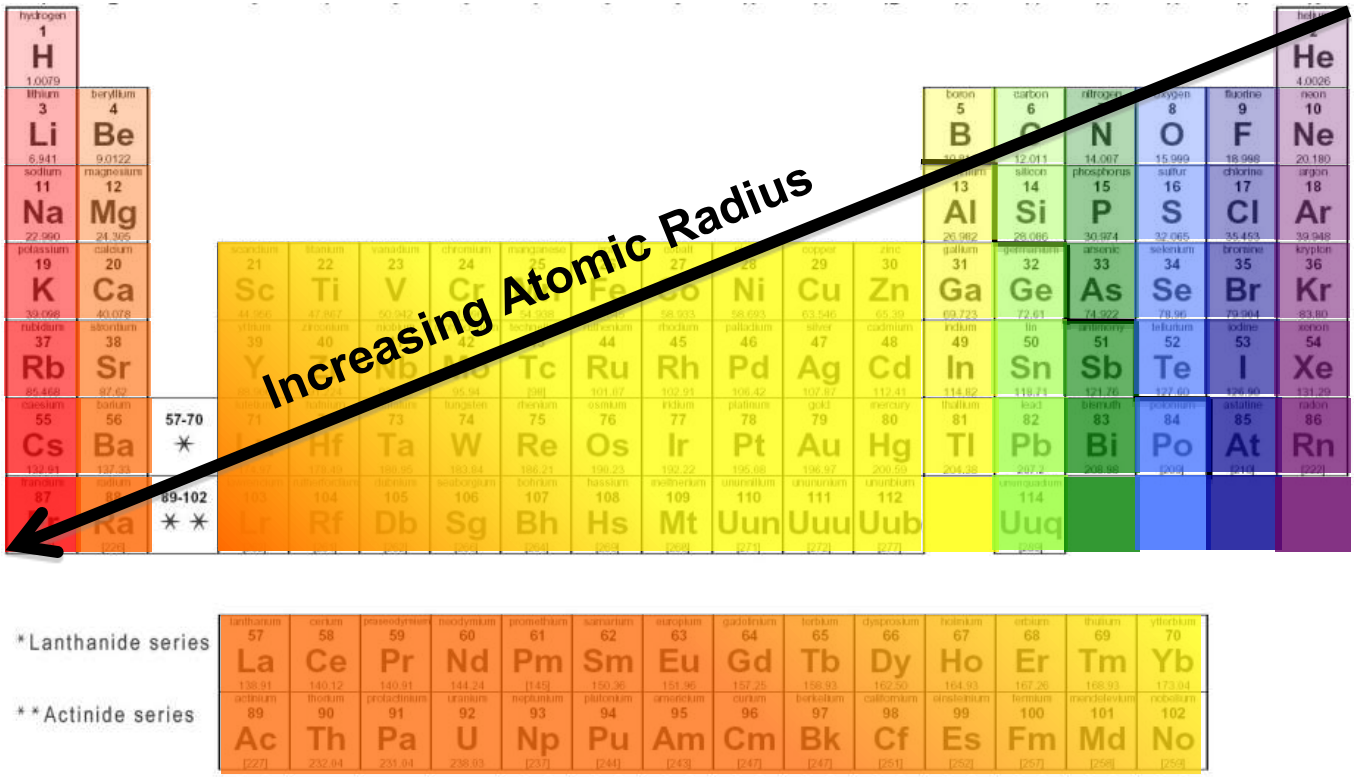
September 4, 2011

11. Periodic Table III



Review

- Many elemental properties follow periodic trends across the rows and columns of the Periodic Table
- Atomic radii increase going down and to the left on the Periodic Table



What is responsible for the increase in atomic radii in a row? In a column?

Review

- Place the following elements in order of increasing atomic radii:

Mg **Na** **Ne** **F** **O**

Review

- What is the electron configuration for each atom after …

O	F	Ne	Na	Mg
$[He]2s^2 2p^4$	$[He]2s^2 2p^5$	$[Ne]$	$[Ne]3s^1$	$[Ne]3s^2$
… adding 2 electrons?	… adding 1 electron?		… removing 1 electron?	… removing 2 electrons?
↓	↓	↓	↓	↓
O^{2-}	F^-	Ne	Na^+	Mg^{2+}
?	?	?	?	?

Review

O	F	Ne	Na	Mg
$[He]2s^2 2p^4$	$[He]2s^2 2p^5$	$[Ne]$	$[Ne]3s^1$	$[Ne]3s^2$
+ 2 e⁻	**+ 1 e⁻**		**- 1 e⁻**	**- 2 e⁻**
↓	↓	↓	↓	↓
O^{2-}	F^-	Ne	Na^+	Mg^{2+}
$[Ne]$	$[Ne]$	$[Ne]$	$[Ne]$	$[Ne]$
		$[He]2s^2 2p^6$		

These ions and atoms are all **isoelectronic**.

Today we will learn trends in their (ionic) radii and reactivity.

Outline

- Special Groups
- Salts
- Ionic Radii

- Special Groups
  - Noble Gases
  - Alkali Metals
  - Halogens
- Salts
- Ionic Radii

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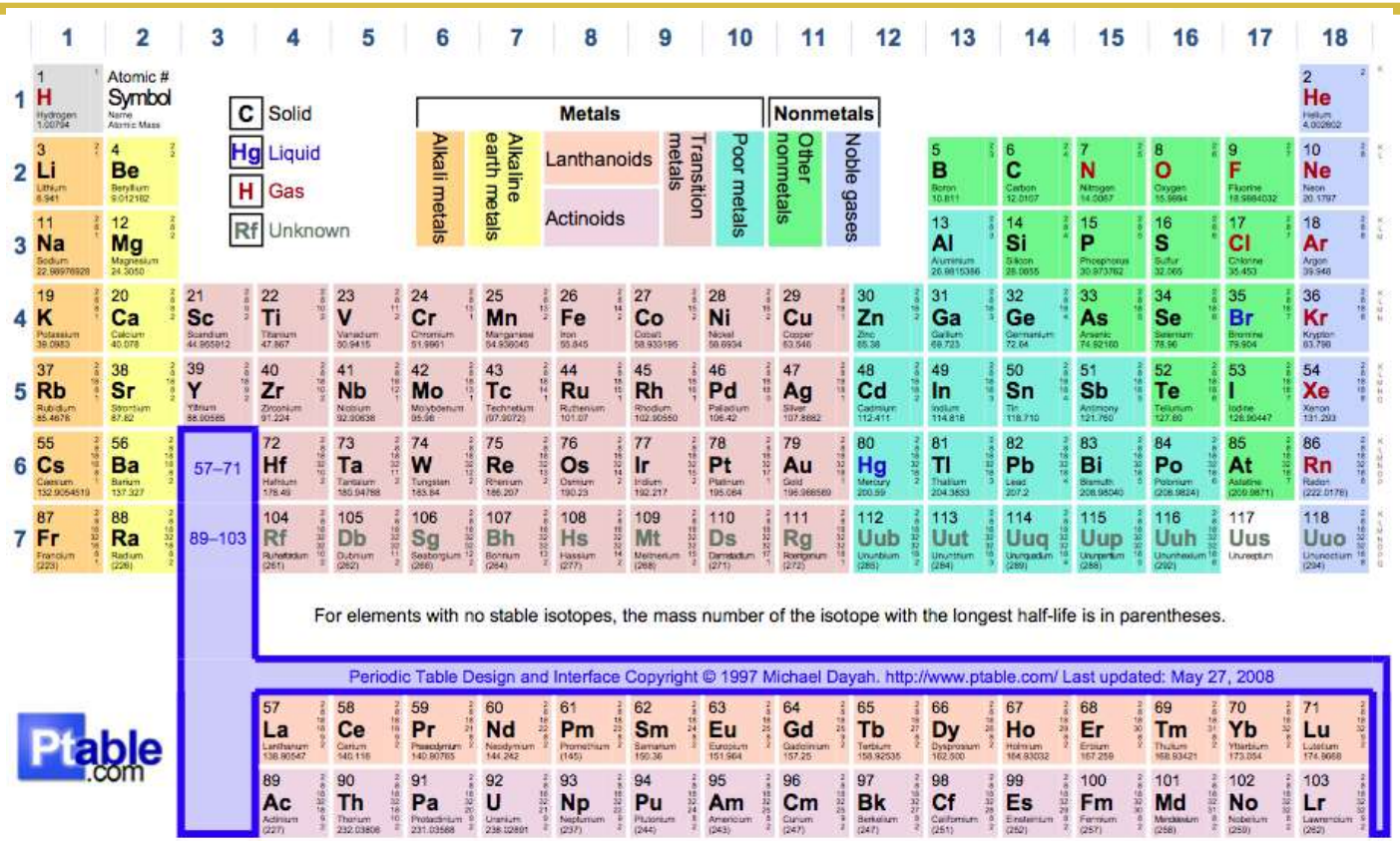
Periodic Table

- Special Groups: What properties do the elements in each have in common? What is the origin of these common properties?

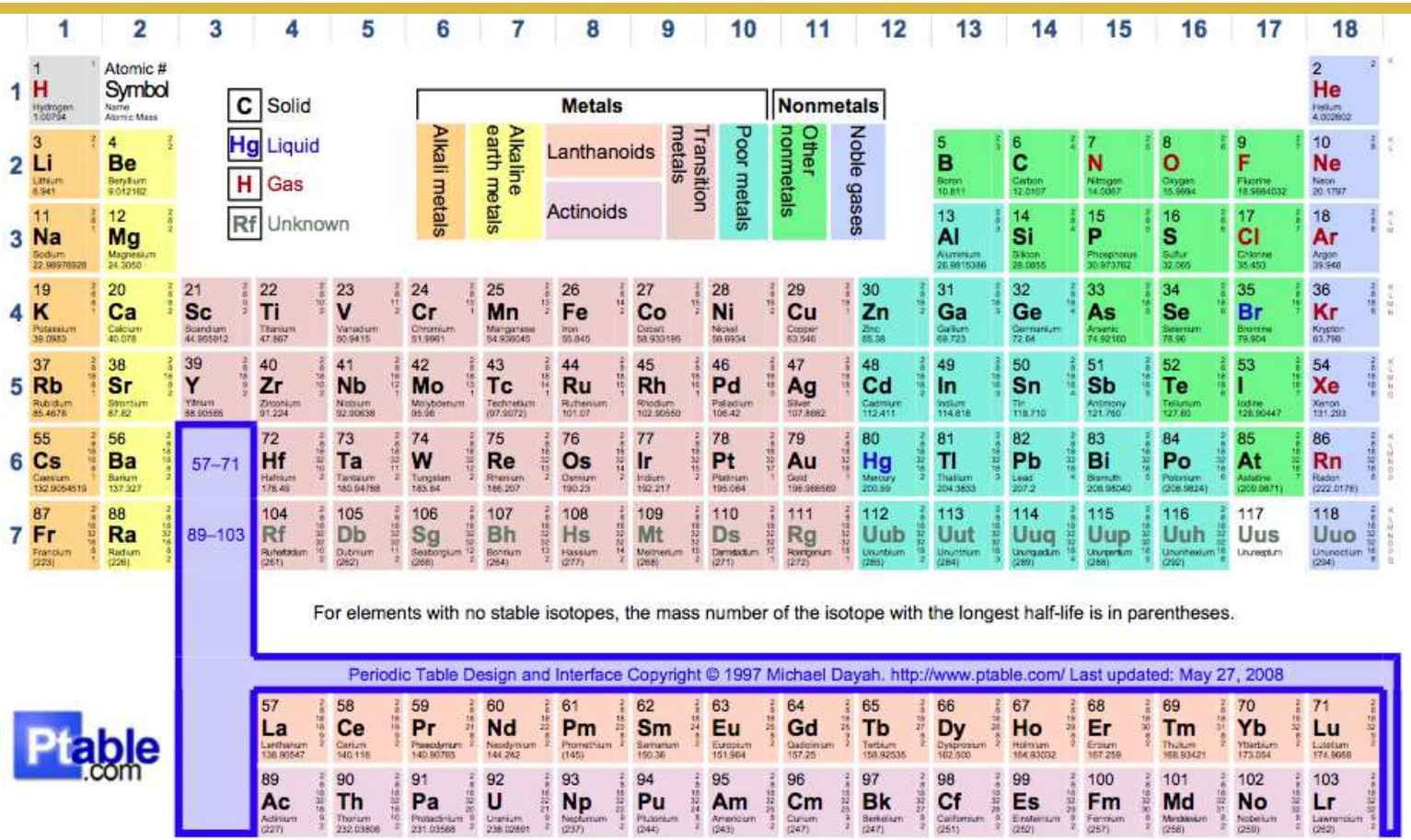


Electron configuration!

Chemistry **IS** the transfer of electrons between atoms.

Periodic Table

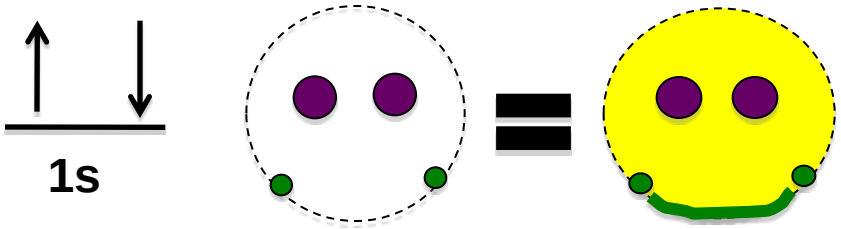
- Atoms and ions with **full valence shells** are the **most stable** (have the **lowest energy**)
- Atoms **transfer or share valence electrons** in order to **fill their valence shells**



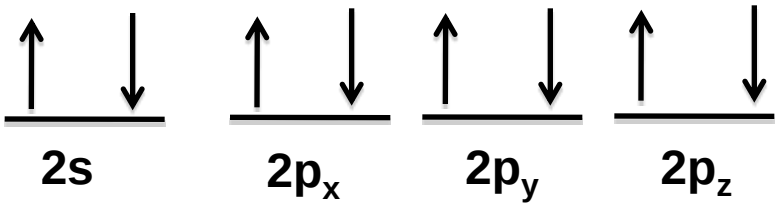
Noble Gases

- **Noble gases** are **extremely stable** because their electrons completely fill their outermost shell

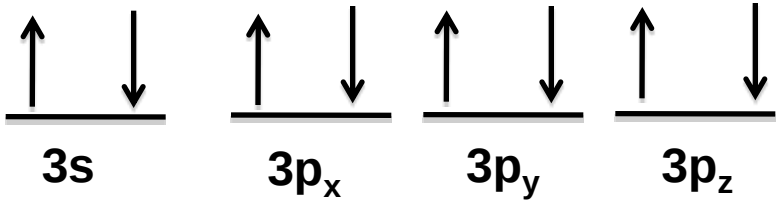
He $1s^2$



Ne $[He]2s^2 2p^6$ **[He]**

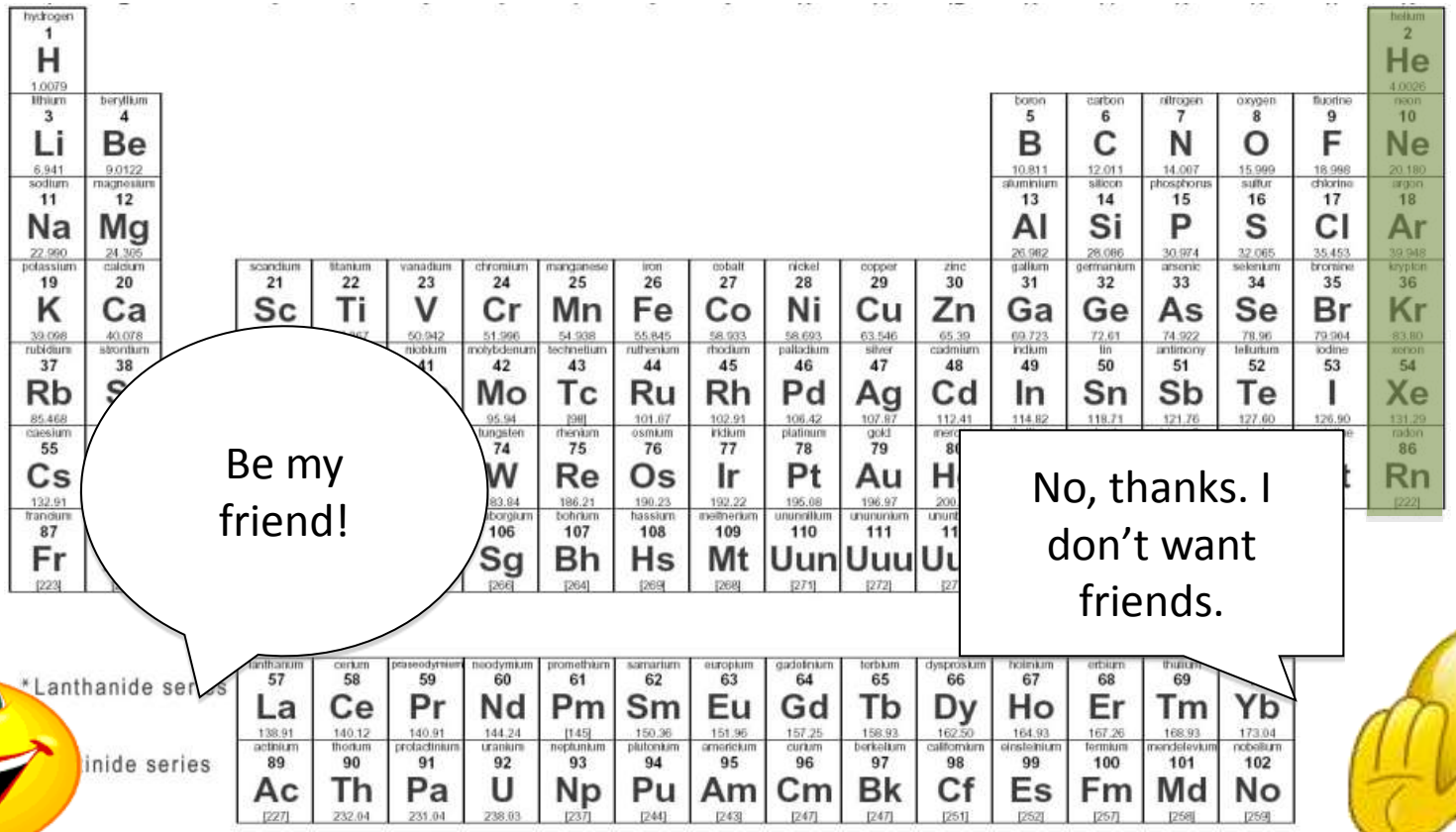


Ar $[Ne]3s^2 3p^6$ **[Ne]**



Noble Gases

- **Noble gases** are also called **inert gases**, since they are **so stable** that they **don't react** with many other elements



Other Elements

Noble Gases

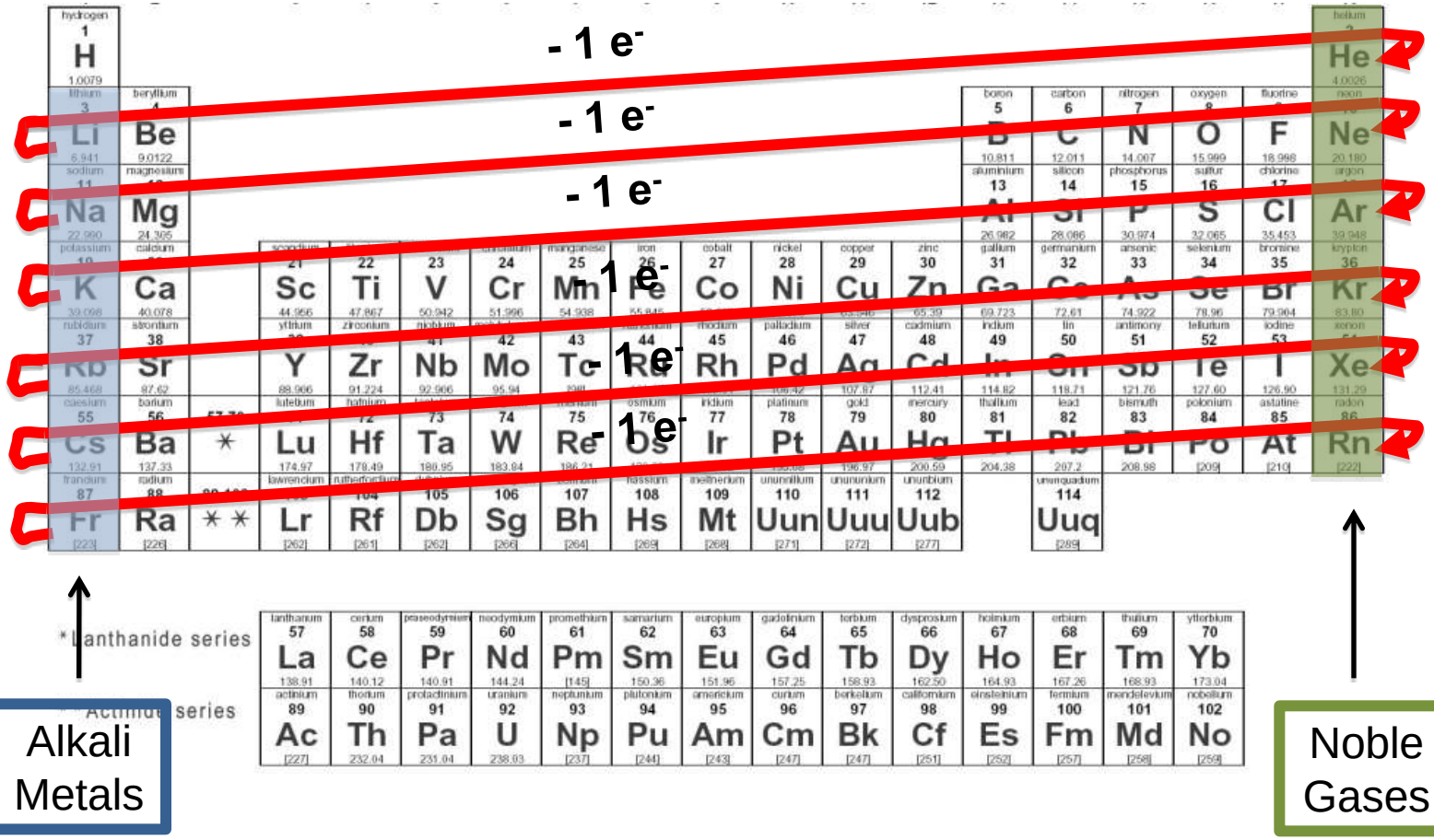
Outline

- Special Groups
- Salts
- Ionic Radii

- Special Groups
  - Noble Gases
  - Alkali Metals
  - Halogens
- Salts
- Ionic Radii

Alkali Metals

- **Alkali metals** have one more electron than noble gases
- To attain a stable**, noble-gas electron configuration**, alkali metals **lose 1 electron** to become +1 cations



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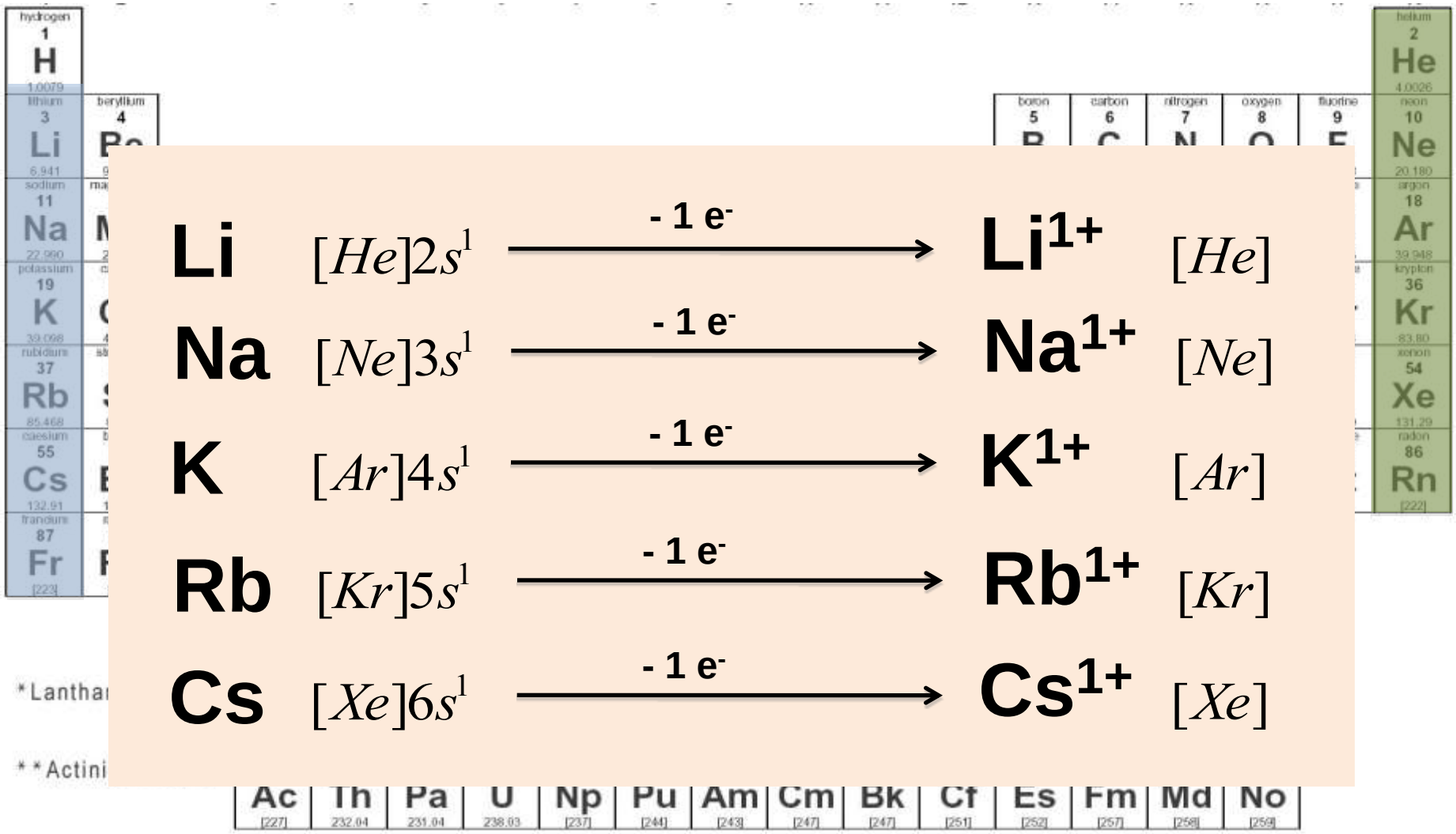

Outline

- Special Groups
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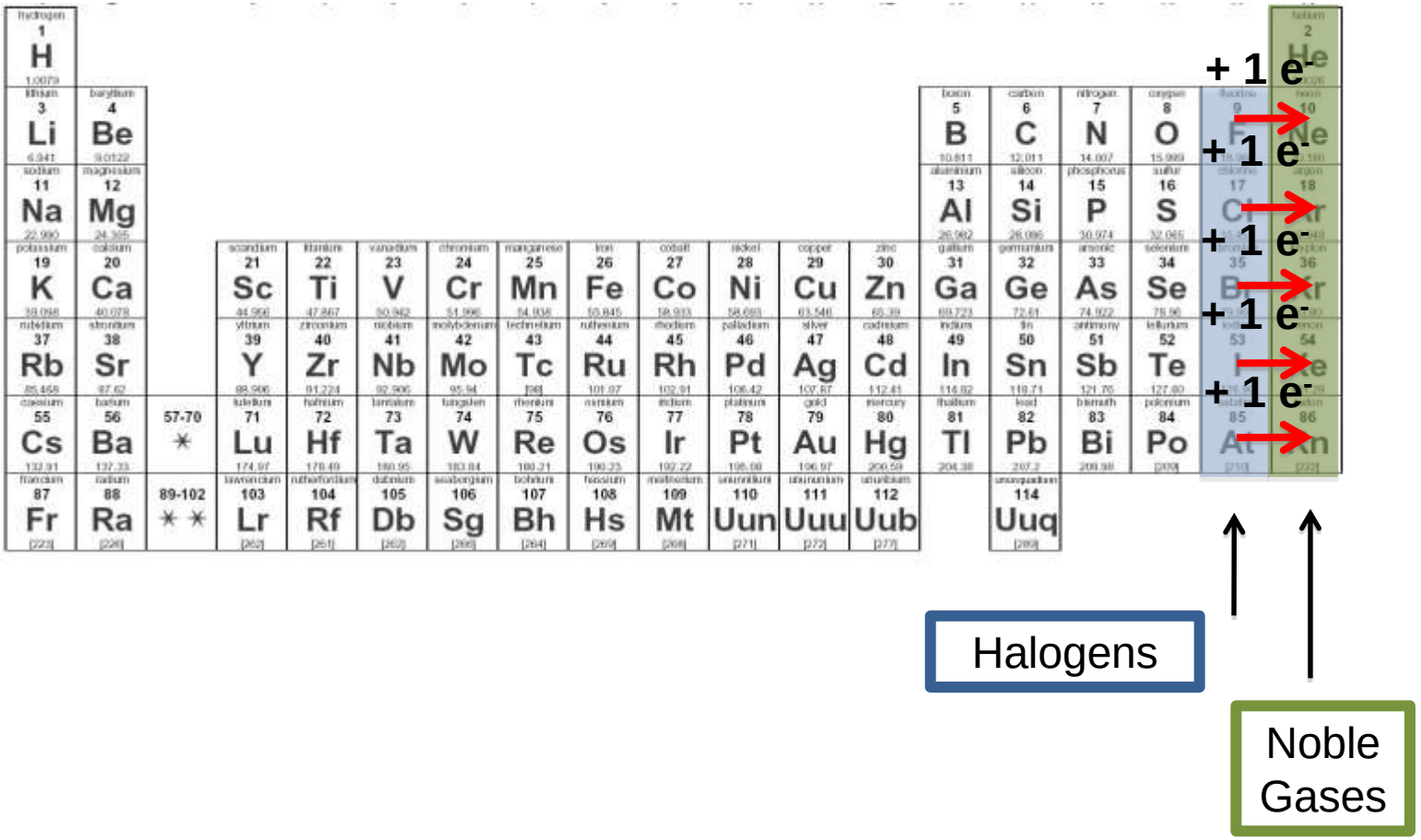
Halogens

- **Halogens** have one fewer electron than noble gases
- To attain a stable, **noble-gas electron configuration**, halogens **gain 1 electron** to become -1 anions



Halogens

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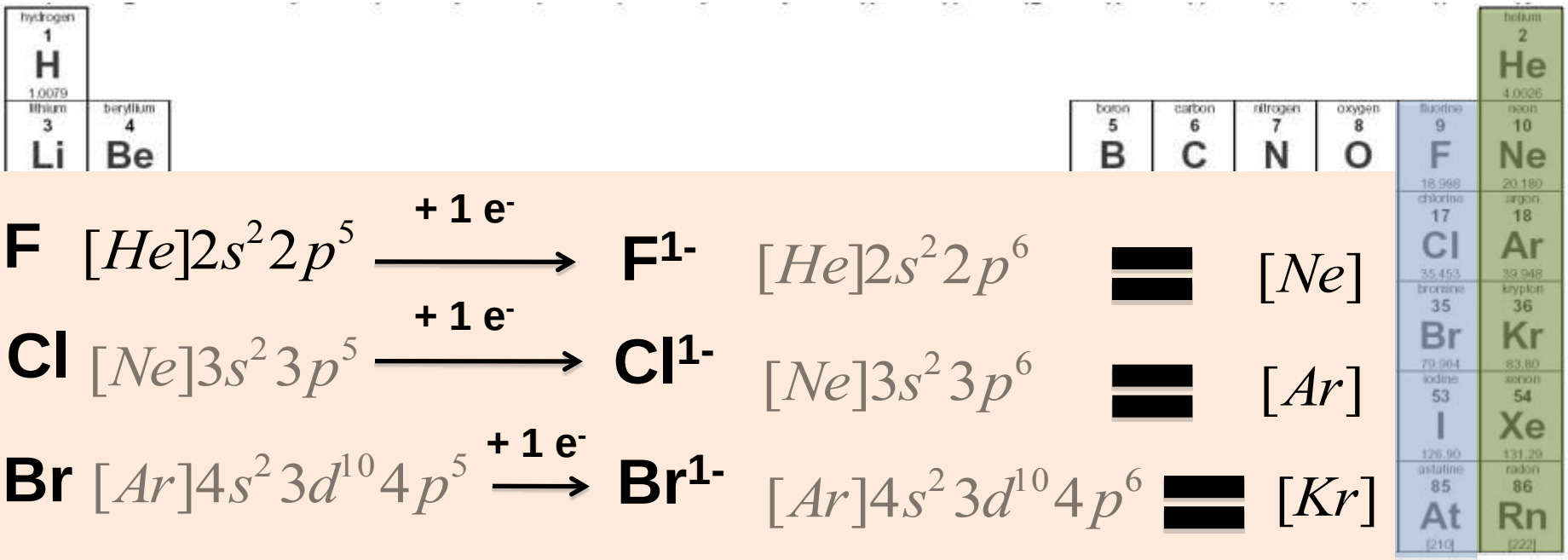
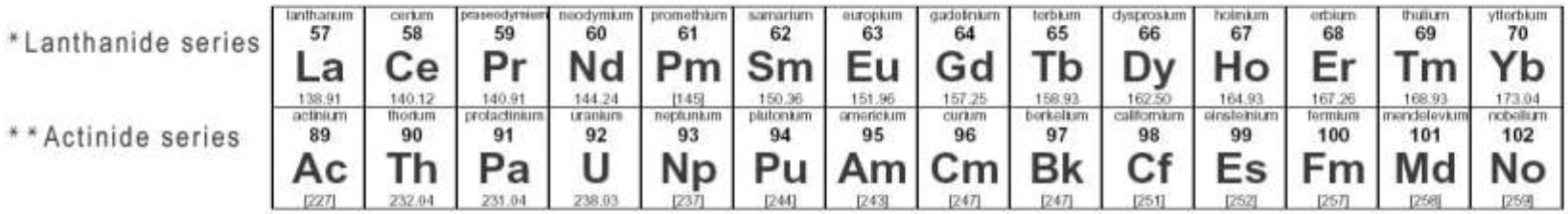
- To attain a stable, noble-gas electron configuration, alkali metals lose 1 electron to become +1 cations





Outline

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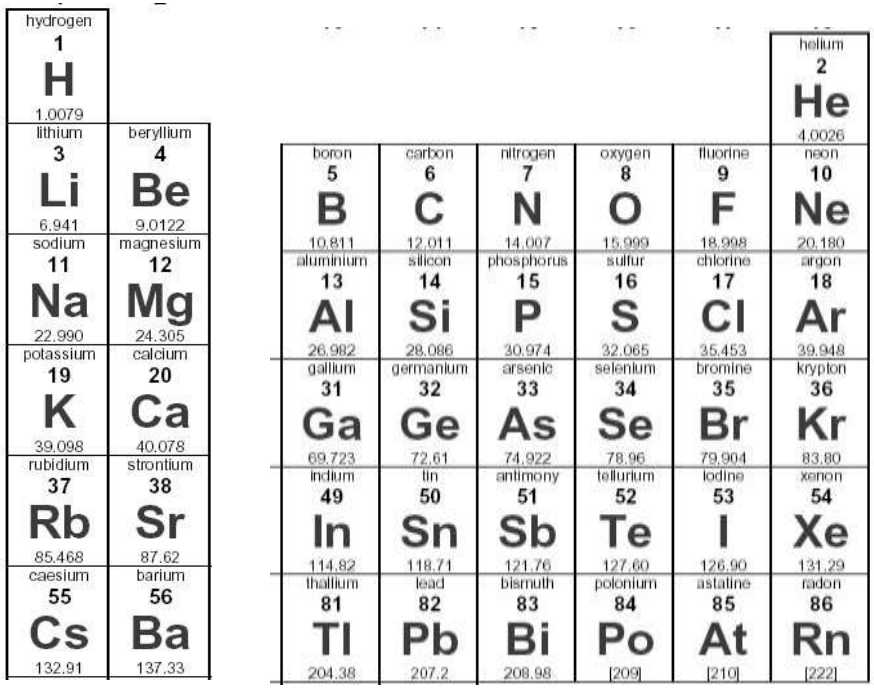
Other Atomic Ions

- Just like alkali metals and halogens, atoms of other elements lose or gain electrons to gain noble-gas electron configurations

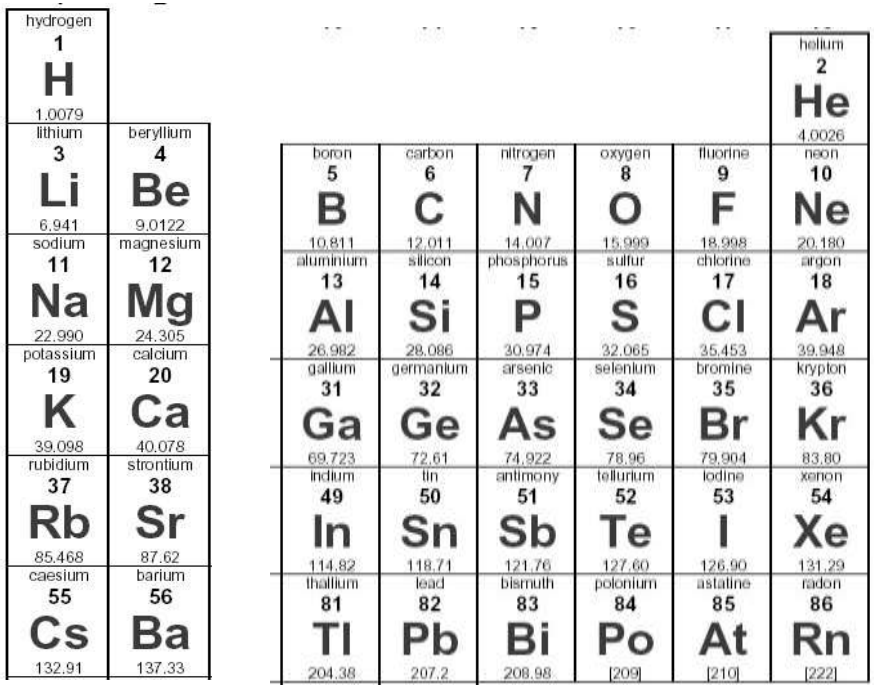


How many electrons do the atoms in each group above need to lose or gain to be like noble gases?

1	?	?	?	?	?	1	0	**Electrons lost / gained**
+1	?	?	?	?	?	-1	0	**Ionic charge**

Other Atomic Ions

- Just like alkali metals and halogens, atoms of other elements lose or gain electrons to gain noble-gas electron configurations

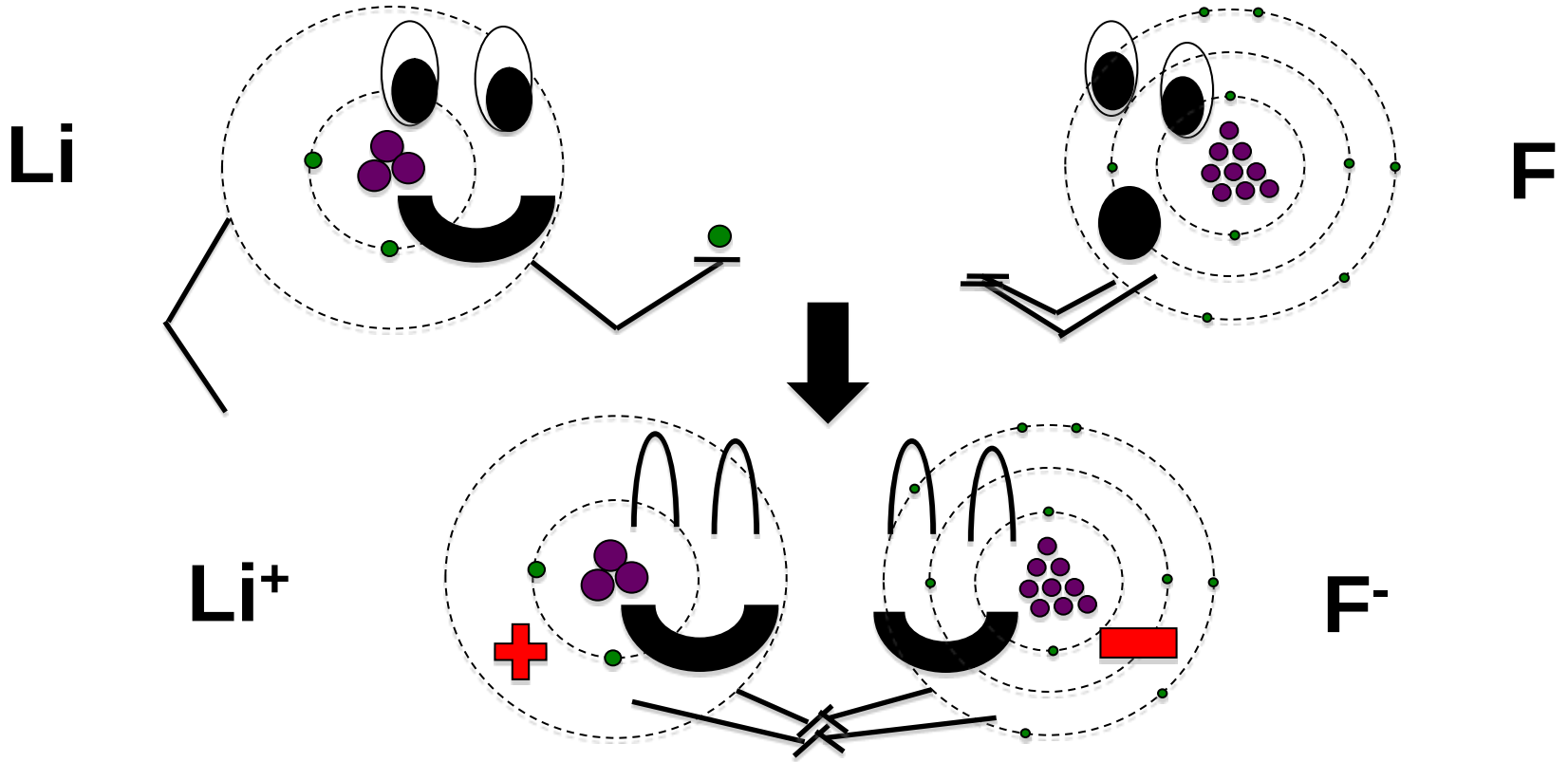


How many electrons do the atoms in each group above need to lose or gain to be like noble gases?

1	2	3	4	3	2	1	0	Electrons lost / gained
+1	+2	+3	+4	-3	-2	-1	0	Ionic charge

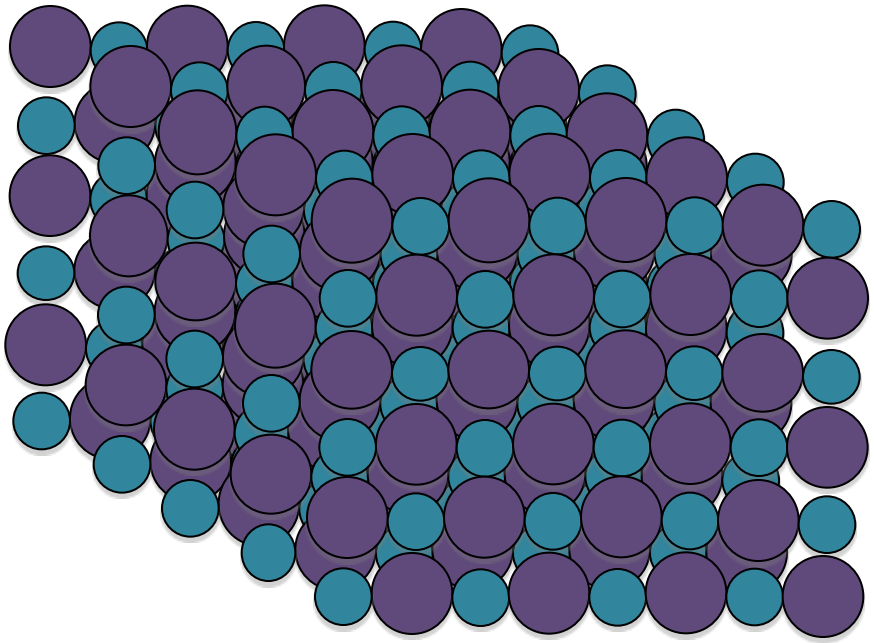
Salts

- **Alkali metals give up** an electron to become cations
- **Halogens accept** an electron to become anions
- **Cations** (positively charged ions) and **anions** (negatively charged ions) **attract** each other strongly.



Salts

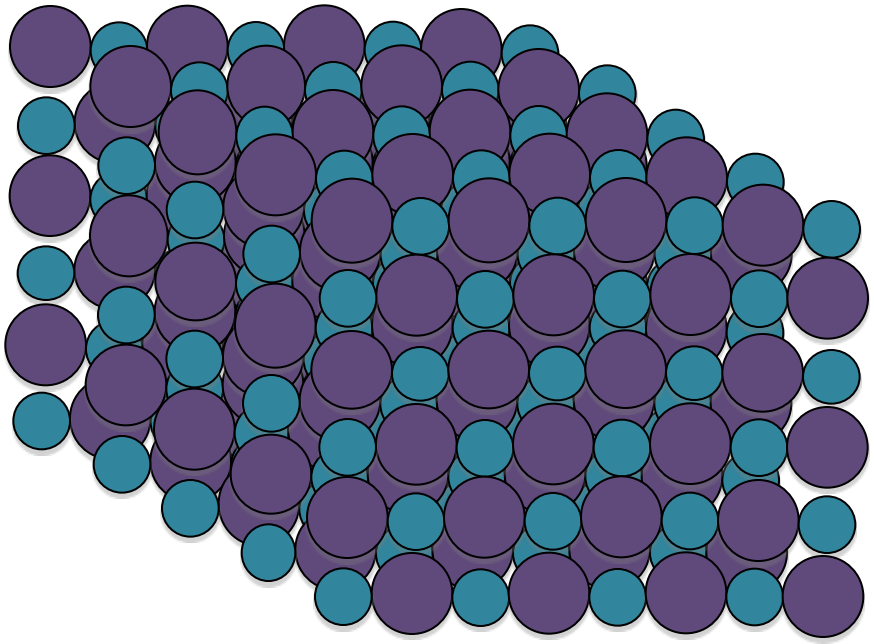
- **Salts** are **crystalline solids** of cations and anions



Cl^- Na^+

Salts

- **Salts** are **very stable** due to the strong attraction of cations and anions



Because they need to give up or accept only **one electron**, **alkali metals** and **halogens** are very **reactive**.

Let's see what happens when we place a small amount of (some alkali metal) in water …

Cl^- Na^+

Outline

- Special Groups
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  - Halogens
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Mini Quiz

- Rank the following atoms in order of increasing atomic radius:

Ge **O** **C** **Se**

- How many electrons will the following atoms lose or gain to attain fully filled valence orbitals?

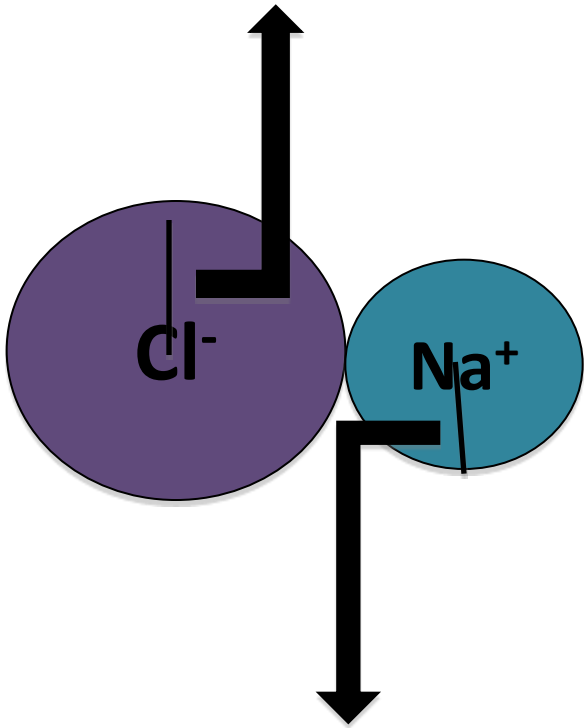
Na **In** **Br** **Bi**

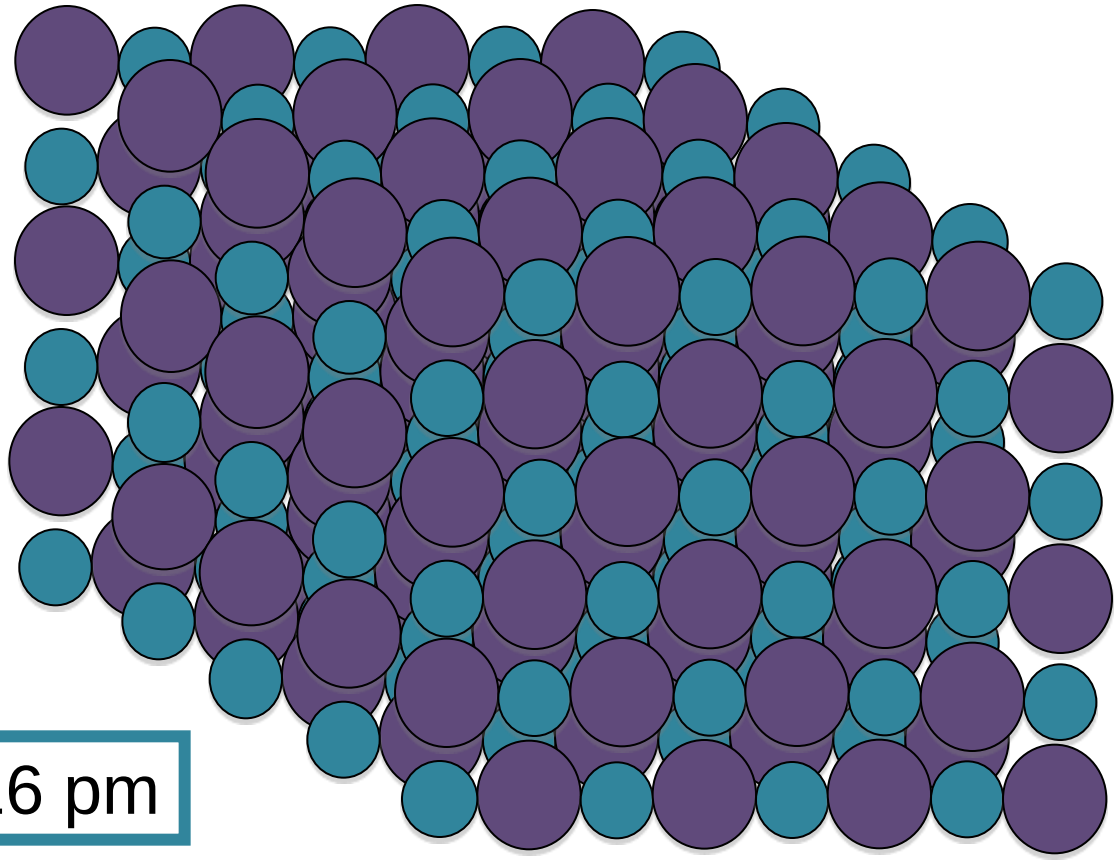
- What would the charges on the ions above after gaining or losing electrons?

Ionic Radii

- We measure the radii of ions by measuring atom-atom distances in ionic solids (salts)

Ionic Radius (Cl^-) = 167 pm

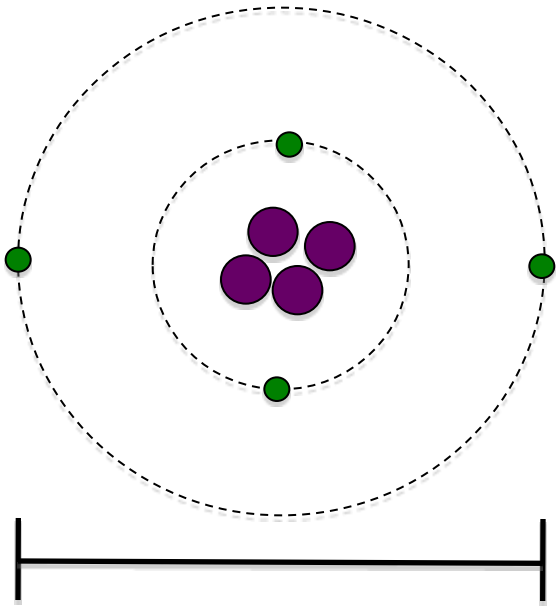




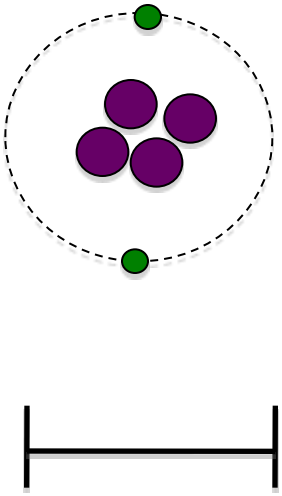
Ionic Radius (Na^+) = 116 pm

Cationic Radii

- Electrons push other electrons farther from the nucleus
- **Removing electrons** from an atom makes the remaining electrons move **closer to the nucleus**



– 2 e^-



Atomic Radius = 90 pm

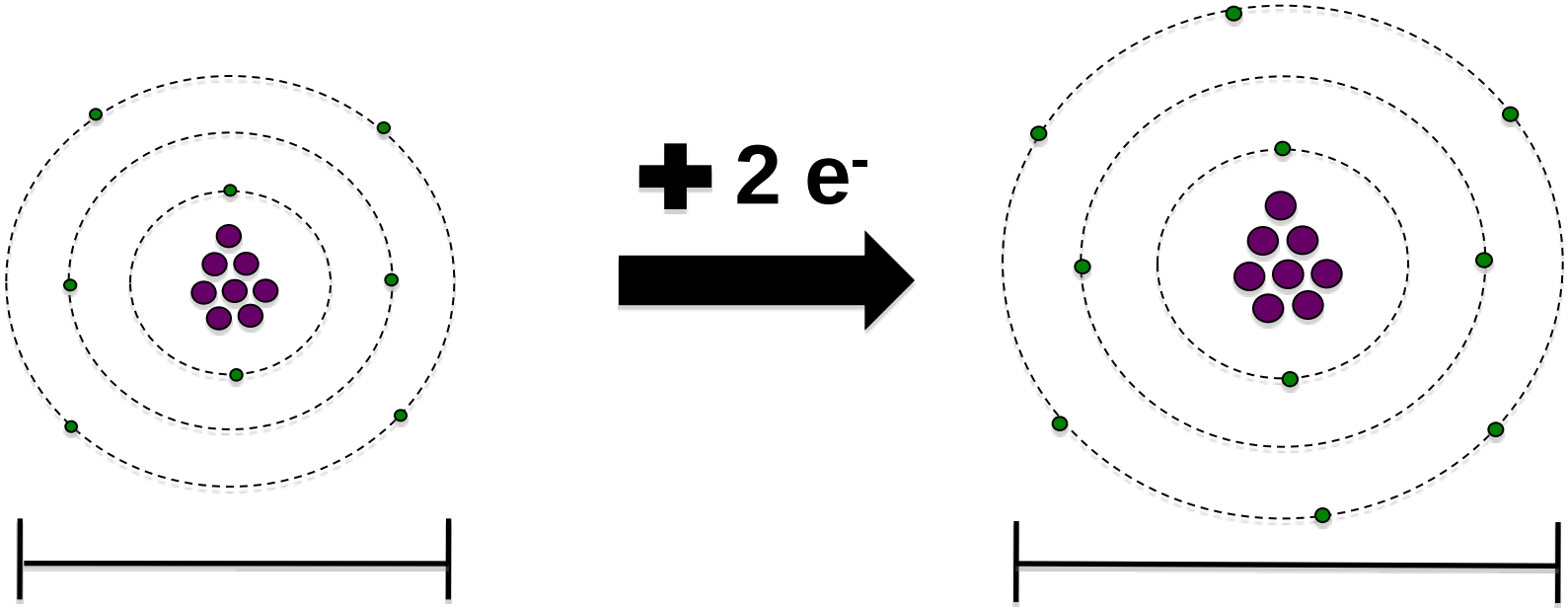
Be

Ionic Radius = 59 pm

Be^{2+}

Anionic Radii

- Electrons push other electrons farther from the nucleus
- **Adding electrons** to an atom makes the remaining electrons move **farther from the nucleus**



Atomic Radius = 60 pm

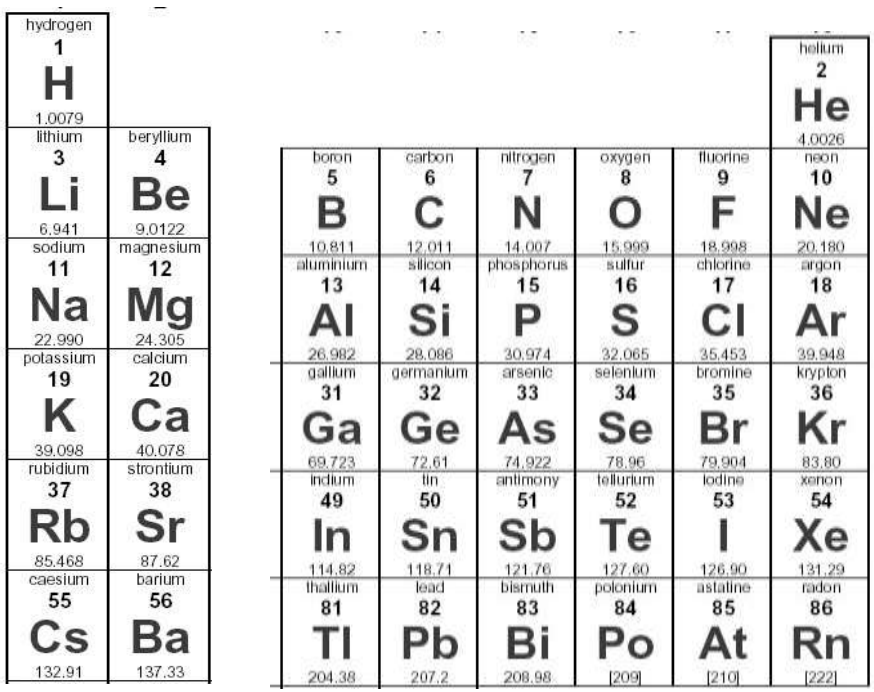
O

Ionic Radius = 126 pm

O^{2-}

Ionic Radii – Periodic Trends

- Just like alkali metals and halogens, atoms of other elements lose or gain electrons to gain noble-gas electron configurations



Compared to neutral atom …

Positive Charge

Ionic Radius

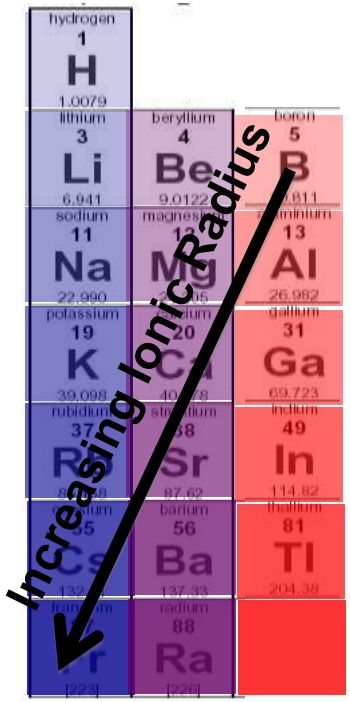
Negative Charge

Ionic Radius

1	2	3	4	3	2	1	0	Electrons lost / gained
+1	+2	+3	+4	-3	-2	-1	0	Ionic charge

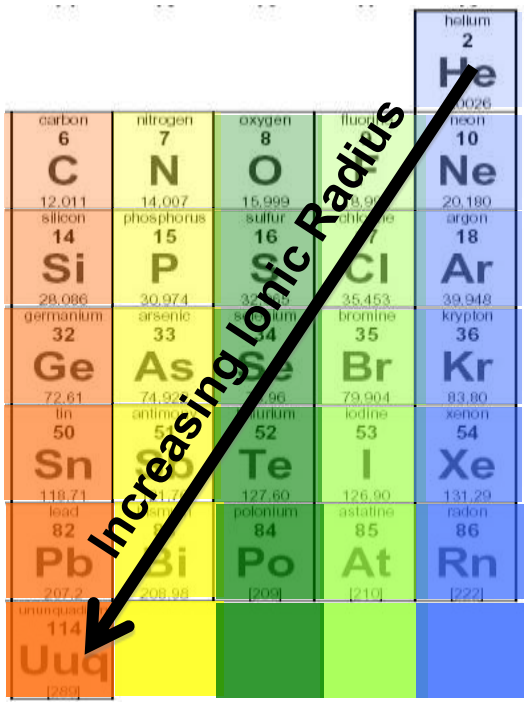
Ionic Radii – Periodic Trends

- Because **cations** are **smaller** than neutral atoms and **anions** are **larger** than neutral atoms, ionic radii follow a more complicated trend.



Cations

Ionic Radius smaller than Atomic Radius

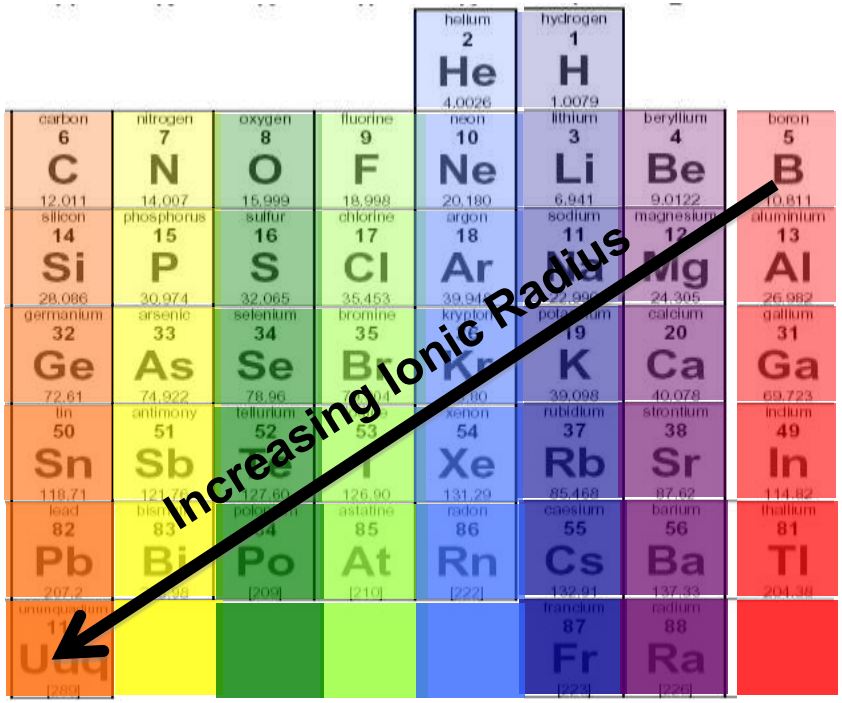


Anions

Ionic Radius larger than Atomic Radius

Ionic Radii – Periodic Trends

- Rearranging the periodic table, we see that ionic radius approximately increases going from the smallest 3+ cation (B 3+) to the largest 4- anion (Pb 4-)



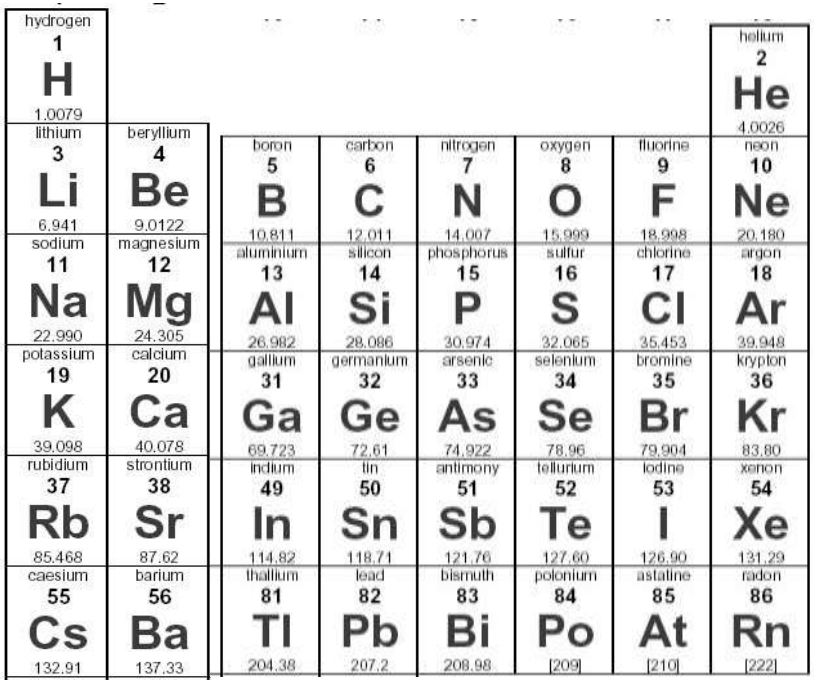
Anions
Ionic Radius larger than Atomic Radius

Cations
Ionic Radius smaller than Atomic Radius

Isoelectronic Atoms and Ions

- Two atoms or ions with the same number of electrons are **isoelectronic**
- When comparing two isoelectronic atoms or ions, the one with the **greater positive charge** has **the smaller radius**
- When comparing two isoelectronic atoms or ions, the one with the **greater negative charge** has **the larger radius**

- **He**
- **H^-**
- **Li^+**



Mini Quiz

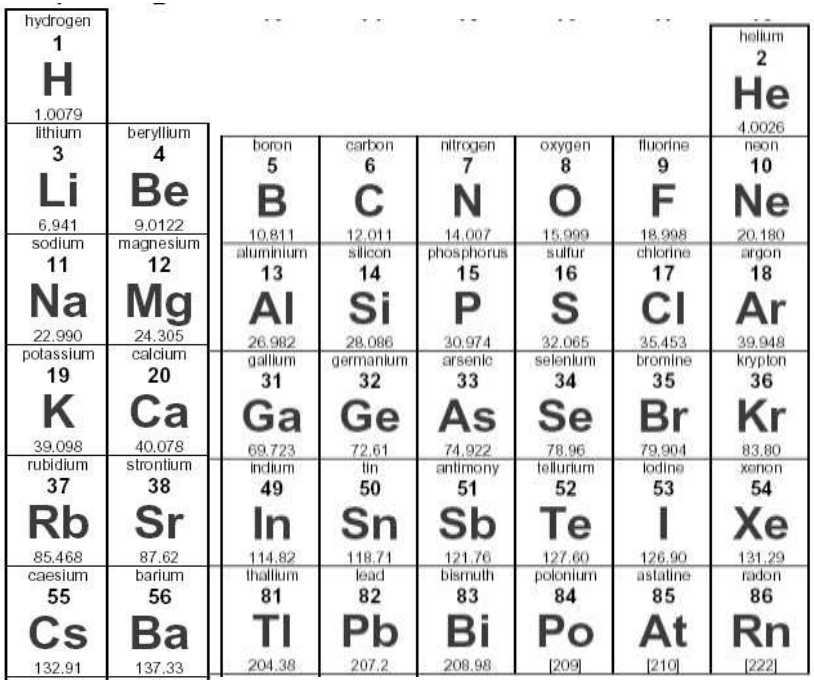
Place the following ions in order of increasing atomic radius

Mg^{2+} Cl^{-} P^{3-} Na^{+}

Place the following ions and atom in order of

increasing atomic radius

Kr Rb^{+} Br^{-}



Summary

- Atoms lose or gain electrons to attain filled outer shells (noble-gas configurations)
- Salts form from anionic and cationic atoms
- Ionic radii are larger (smaller) in anions (cations) than in neutral atoms

Homework

- TBD